Quality Assurance Project Plan
for the

PERFORMANCE OF FOUR BEST MANAGEMENT PRACTICES FOR HIGHWAY RUNOFF IN BEAUFORT AND COLLETON COUNTIES, SOUTH CAROLINA

Prepared for the
SC Department of Transportation

By the

US Geological Survey
Water Resources Investigations
Columbia, South Carolina

September, 2004

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Program Manager	**Principal Investigator**
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Performance of four best management practices for highway runoff in Beaufort and Colleton counties, South Carolina

Project Management

Program Distribution List:

Mr. Kevin Conlon	USGS Project Lead Co-Investigator
Mr. Toby Feaster	USGS Program Manager
Ms. Martha Harrison	General Engineering Labs, Project Manager
Mr. Noel Hurley	USGS S.C. District, Assistant District Chief
Ms. Celeste Journey	S.C. District Water-Quality Specialist, Technical Science Support
Mr. Brady Long	USGS Hydrologic Technician
Mr. Eric Strom	USGS South Carolina District Chief
Mr. Ray Vaughn	S.C. DOT – Program Manager

Project Organization:

South Carolina DOT – USGS cooperative Project

Agency Responsibilities:

The USGS will provide the organizational lead for the management and oversight of the program. Primary responsibility for convening the project's partners and coordination of program components will rest with the Program Manager, with the technical assistance of the Co-Investigators. The USGS will have primary responsibility for monitoring stream flow, stage, rainfall, pH, specific conductance, and water temperature during select storm events at the four sites listed in a later section. During the data-collection period, the USGS also will collect water samples for selected water-quality constituents at the inflow and outfall of each BMP structure during 15 storm events.

Project Personnel:

The USGS Co-Investigators will be Kevin Conlon, and Toby Feaster. Kevin Conlon will serve as the lead USGS investigator for this project. Toby Feaster will assist Kevin Conlon in analyzing and interpreting the data. Noel Hurley, Jr. will assist with overall project and personnel coordination and management.

Mr. Kevin Conlon is a Hydrologist with the USGS in Charleston, SC. He is currently a project member of a study to determine the geochemical and hydrologic effects of long-term storage of treated surface water in limestone aquifers in Charleston, SC.

Mr. Toby Feaster is the Surface-Water Specialist for the USGS, South Carolina District and has been involved in water investigative studies with the USGS since ??. Most recent projects included Mr. Noel Hurley, Jr. has served since August 1997 as the Assistant District Chief and Chief of the Hydrologic Investigations Section for the USGS, South Carolina District. The Hydrologic Investigations Section currently consists of 16 individuals including engineers, geologists, a biologist, and graphic illustrators. Recent projects undertaken by this section include surface water, ground water, and water quality assessments, such as: investigation of the feasibility of using Aquifer Storage Recovery in the Charleston, SC area to supply an emergency source of drinking water; investigation of salt-water intrusion into the Floridian Aquifer in coastal Georgia; development of flow and transport models for the Catawba and Wateree Rivers; clear-water scour analysis for selected bridges in SC; and development of equations to estimate the magnitude and frequency of peak flow for SC streams.

Mr. Brady Long is a Hydrologic Technician with the USGS in Charleston, SC. Mr. Long will lend support during the sampling phases of the project, and will service the water quality and water level instruments located at the four sites. Mr. Long currently operates and maintains surface water quality gauging stations located throughout the Tri-County area. He was responsible for all USGS surface water

quality monitoring stations involved with the Charleston Harbor Project from 1992-95. Mr. Long is an instructor for the U.S. Department of Interior Motorboat Operator Certification Course.

Problem Definition:

As part of National Pollutant Discharge Elimination System (NPDES) stormwater program mandated in the Clean-Water Act, the South Carolina Department of Transportation (SCDOT) is required to address the quality of stormwater runoff from state-maintained roadways. Stormwater discharges from state roadways are considered a large municipal separate storm-sewer system (MS4) by the NPDES program and require development of a proposed storm-water management program that would meet the standard of "reducing pollutants to the Maximum Extent Practicable (MEP)" (South Carolina Department of Health and Environmental Control, 2001). Municipal separate storm sewer systems or MS4s are defined as a conveyance or system of conveyances for stormwater that includes roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains.

To mitigate the effects of runoff from state roadways to area water bodies, the SCDOT has installed 11 structural Best Management Practices (BMPs) along approximately 2 miles of Route U.S. 21 in Beaufort, S.C. between the bridge crossing the Beaufort River and the bridge crossing Chowan Creek (fig. 1). These BMPs include a grassed waterway, a detention pond, and 9 vendor-supplied systems developed by Stormceptor (5), CDS Technologies (3) and Vortechnics (1). In addition, the SCDOT has installed vendor-supplied devices throughout South Carolina, including devices developed by CrystalStream Technologies at the I-95 rest areas in Colleton County (fig. 2). Many of these systems incorporate some combination of filtration media, hydrodynamic sediment removal, oil and grease removal, or screening to remove pollutants from stormwater. There exist little comparative data of the effectiveness of these technology structures at their current locations. Available data do not account for changes in environmental factors among sites or for variability in event-mean concentrations. Previous studies did

not include sufficient samples to provide for statistically robust evaluations of differing removal efficiencies among the various BMP structures.

Program Objectives and Description:

The USGS and the SCDOT propose to work cooperatively to collect sufficient data to:

- determine event-mean concentrations,
- calculate loads entering and leaving the BMPs,
- estimate the removal efficiency of the commercially available BMPs for selected constituents such as suspended sediment, metals, oil and grease, and fecal indicator bacteria in roadway runoff, and,
- evaluate the relation of water-quality constituents to average daily traffic (ADT) data by correlation analysis.

Quality Objectives and Criteria:

The quality objectives for the Best Management Practices Program are based on standards necessary to achieve the overall program objectives presented above. In sum, the program's intent is to quantify and characterize stormwater runoff and the effects of its treatment by in-place BMP structures, at four sites, and to determine the effectiveness of those structures in treating the runoff.

Precision

Storm-event samples for analysis will be collected using automated sampling equipment and as grab samples by field personnel. Replicate samples and split samples will be analyzed to measure precision, or the degree of agreement among repeated measurements of the same analyte as well as the reproducibility of laboratory results. For sediment composition samples, laboratory personnel will reanalyze a subset from each batch of samples, allowing a difference of no more than 10percent as the criteria for acceptance. For sediment contaminant samples, laboratory personnel will assess the precision

for each analyte by evaluating the recovery rates from standard reference materials (SRMs). Additional information detailing methods to be used to insure sampling precision can be found in subsequent sections of this plan.

Accuracy

Accuracy of sampling results will be measured through the use of spikes, SRMs, and blanks. The quality control samples will be analyzed for each group of samples for each analytical method. Further details regarding methodologies to be used are provided in Tables 2-7.

The procedures to be utilized for collecting, storing and shipping samples to insure their integrity are detailed in other sections of this document.

Comparability

All field personnel and laboratory workers will use standardized methods of sampling, analysis and reporting described in subsequent sections of this plan. These include National Water Quality Assessment Program protocols, participation in a National Field Quality Assurance Program, and other established programs of the U.S. Geological Survey. As sampling occurs during 15 storm events over the course of 12-13 months, the consistency of methodology will enhance comparison of later sampling data with earlier results.

Measurement Range

Instrument calibration and maintenance requirements, and laboratory reporting levels are described later in this plan.

Special Training Requirements:

USGS field personnel assigned to this project are required to have completed the following safety training: American Red Cross first-aid and CPR course; and Procedures for entering and working in confined spaces. Field personnel also will follow the guidelines set forth in the USGS, Water Resources

Division Memorandum 99.32, *Water Resources Division Policy for Safety Associated with Discharge Measurements, Sampling, and Related Streamgaging Activities*.

Field personnel will be required to have attended training sessions taught by certified USGS personnel on National Water Quality Assessment Program (NAWQA) clean hands sampling protocols and operation, calibration, and servicing of water quality sensors for portable monitoring equipment. In addition, selected personnel have attended a USGS National Training Center course on the operation and maintenance of continuous monitors. This course presents the general quality assurance concepts and theory for the operation of continuous water quality monitors.

Documentation and Records:

All field sampling efforts and samples collected will be recorded on data forms currently in use by USGS and General Engineering Laboratories, LLC (GEL), of Charleston, South Carolina. The Basic Station Data form will be used to record the sampling date, location, time and type of sample collected, unique sample collection number, station code and other pertinent information as required for the project. All GEL sample-tracking forms will be maintained in master notebooks under the Lab Manager's supervision. These forms will be used to track the status of sample processing and indicate who processed the sample. Quality assurance and control (QA/QC) forms will be used as part of the quality check for the sediment samples. A general summary of the sample processing protocols for the bacteriological sampling component is provided in a subsequent section.

All field measurements and calibration data of continuous water quality monitoring equipment and water quality field meters will be recorded on standard USGS Surface Water Quality Field Notes sheets (Appendix 2). The Field Notes sheets will include the following information: (1) project number, (2) location, (3) date and time, (4) field parameters, (5) instrumentation make/model, (6) instrumentation serial numbers and calibration data, (7) names of people performing work, (8) weather conditions, (9) sample collection time, (10) unique sample collection number, (11) type of sample collected, (12)

preservatives used, (13) laboratory schedules, (14) blanks, and other information required for the project. All Field Notes sheets will be completed in ink, on-site.

The original Field Notes sheet will be returned to the USGS office and placed in the current folder file for each corresponding station. Field Notes sheets and real-time data will be used during the records computation phase. The records computation process is used to verify the data and document its quality. The primary steps in processing the records are an initial data evaluation, application of corrections and shifts, and a final data evaluation. The processed data are assembled into a final data package, which is then checked and reviewed by other USGS personnel. Once approved, this final data package is published in the USGS Annual Report and archived within the USGS (Hubbard, 1992). Data collected on paper and/or electronically will be stored either in the USGS National Water Information System (NWIS) QWDATA data base (Maddy and others, 1997) or in the NWIS Automated Data Processing System (ADAPS) database (Dempster, 1990). The NWIS is the storage medium for water quality, streamflow, well, and water use information collected by the USGS.

Sample-collection information also will be recorded on standard USGS Surface Water Quality Field Notes sheets mentioned in the previous section. All Field Notes sheets will be completed in ink on-site at the time of sampling. The original Field Notes sheet will be returned to the USGS office and placed in a bound notebook maintained by field personnel. USGS National Water Quality Laboratory (NWQL) Analytical Services Request forms (ASR) (Appendix 4), will be used to record data and will be submitted with the samples to the appropriate lab. Protocols for labeling, documenting, and packaging samples will be in accordance with Wilde and others (1999). All water-quality data will be electronically transferred from the databases of NWQL to the NWIS QWDATA database, which is retrieved by the SC District Data Base Administrator at least once a week (Wang, 1999). Data submitted by laboratories other than the NWQL will be manually entered into NWIS database (Hubbard, 1992).

Measurements/ Data Acquisition

Sample Collections and Handling:

All sampling and data collection during this study will be in accordance with standard USGS guidelines, as stipulated below.

USGS Streamflow, Stage, and Rainfall Measurements:

The data-collection equipment described is stored in a gage house constructed at each site. The gage houses are walk-in shelters approximately 6 by 8 feet, and provide sufficient area to store the sampling equipment as well as workspace to prepare samples for shipment. Direct connection to electrical lines or batteries and solar panels provides power for the equipment. A raingage has been installed at one of the structural BMPs in Beaufort County and at the I-95 rest area. Data from these gages will quantify the rainfall intensity and duration that triggers sample collection.

Flow and water-level are monitored continuously at each site. Electromagnetic flowmeters have been installed in the inflow pipe upstream of the devices. Velocity and pipe dimensions will be used to calculate flow. Water levels in each treament chamber are measured by a pressure transducer. Data are collected hourly, until rainfall or a change in stage in the treatment chamber is measured. A shorter data-collection interval (such as one or five minutes) is used for the duration of the event. These data are be stored in a datalogger and periodically downloaded and stored electronically at the USGS South Carolina District office in Columbia, South Carolina. Rainfall data is transmitted, in almost real time, by satellite telemetry. In addition, a telephone modem allows access to data in real time. Real-time radio or landline telemetry will be used to contact USGS and SC-DOT personnel at the beginning of a rainfall event that meets a predetermined intensity. USGS personnel will monitor the rainfall and streamflow data and decide if the event meets the criteria for water quality sampling. Sampling will be triggered by change in stage. The sample interval is controlled by data collected from the stage and velocity sensors.

Comment [taa1]: What are the criteria? Should they be listed?

USGS Water-Column Measurements:

Characterization of the water column will be determined by point-in-time stream measurements during sample collections. Hydrolab, YSI or Stevens Greenspan instrumentation (Hydrolab DS3® and DS4®; Hydrolab Reporter®; YSI 85® and 6920®; Stevens Greenspan CS304) will be used to measure temperature, specific conductance, dissolved oxygen, and pH.

USGS Water-Quality Samples:

Storm-event samples will be collected by USGS personnel over the course of 15 events (3-4 per season) during 12-13 months (Table 1). Samples will be collected by automatic sampling devices and by hand (grab samples). The USGS National Water Quality Laboratory (NWQL) in Denver, CO, will analyze water samples for physical properties, nutrient, metal, PAH/base neutral extractable acid (BNA), total organic carbon, and total suspended solids concentrations. General Engineering Laboratories. LLC, in Charleston, South Carolina, will analyze samples for five-day biological oxygen demand (BOD_5) and ultimate BOD concentrations. Personnel at the USGS office in Columbia, S.C. will will analyze samples for fecal coliform bacteria in accordance with standard USGS protocols (Wilde and others, 199).

Table 1. Constituents to be analyzed and sampling frequency for the BMP Project.

Constituent	Sample location	Type of sample	Number of events sampled
pH, conductance	Iinflow/outflow	Sonde	15
Oil and grease	Inflow/outflow	Grab	15
Turbidity	Inflow/outflow	Flow composited	15
Total suspended solids	Inflow/outflow	Flow composited	15
Chemical oxygen demand	Inflow/outflow	Flow composited	15
Nutrients (total phosphorus, ortho phosphate, dissolved ammonia, and dissolved nitrate plus nitrite)	Inflow/outflow	Flow composited	15

Lead, zinc, copper, and cadmium (total and dissolved)	Inflow/outflow	Flow composited	15
Base/neutral extractable organic compounds (polyaromatic hydrocarbons)	Inflow/outflow	Grab	8
Major ions (calcium, magnesium, hardness)	inflow/outflow	Flow composited	15
Five day biochemical oxygen demand	inflow/outflow	Grab	15
Suspended sediment and Grain size distribution	inflow/outflow	Flow composited	15
Fecal coliform bacteria	inflow/outflow	Grab	15
Grain size distribution of bed sediment	each structural BMP	Grab	1
Bed sediment inorganics	each structural BMP	Grab - composited	1

Automated Sample Collection

Storm event samples for most analyses will be collected using a refrigerated automated sampler equipped with Teflon® tubing and cleaned glass bottles. Quality assurance and quality control procedures will include field equipment blanks to be processed after removing the environmental sample and before cleaning the sampler (at least 10percent of all samples). Automated samplers will collect samples at predetermined intervals to cover the hydrograph. Samples collected by automated sampler will be decanted and discrete samples for trace element and nutrients analysis will be composited in a cleaned polyethylene churn.

Biochemical Oxygen Demand (BOD_5) (General Engineering Laboratories)

Five-day BOD samples are collected in 1,000-ml BOD bottles (provided by GEL) by filling them to the neck and placing the top into the bottle in such a way as to exclude air bubbles. The samples will be placed on ice and transported or shipped to GEL to arrive within 24 hours of collection.

Chemical oxygen demand (NWQL LC 2144)

The sample for analysis of chemical oxygen demand will be collected in a 125-ml amber glass bottle (**COD**), that **IS NOT** rinsed before collection. The bottle will be filled to the shoulder directly from the compositing churn, preserved with 2mL 18N H_2SO_4, chilled to 4˚ C on ice and shipped to the NWQL.

Major ions – Calcium (NWQL LC 659) and Magnesium (NWQL LC 663)

For measurement of major ion concentrations, samples will be taken from the compositing churn, processed through a 0.45-micron glass-fiber filter, and collected in a 250-ml acid-rinsed polyethylene bottle (**FA**) that will be rinsed with filtered sample before being filled to the shoulder of the bottle. After collection, the sample will be preserved with nitric acid by pouring the contents of a pre-measured ampule into the sample.

Nutrients in water (NWQL Schedule 1040 see Table 3 in Appendix))

The samples for nutrients analyses is unfiltered (**WCA**) and is collected directly from the churn by twice rinsing a 125-ml translucent polyethylene bottle with unfiltered sample before filling it. The sample must be acidified with 1 ml of 4.5 N (4.5 normal) H_2SO_4. The sample should be chilled to 4˚ C on ice, and shipped immediately to the NWQL.

Suspended Sediment Grain Size (Kentucky Sediments Lab)

Suspended sediment samples will be collected from the compositing churn by filling two 500-ml glass bottles about ¾ full from the churn's spigot. The USGS Sediment Laboratory in Louisville, Kentucky will analyze samples for grain size distribution.

Total suspended solids (NWQL LC 169)

Samples for total suspended solids (**SUSO**) measurements will be collected in 250-ml polyethylene bottles directly from the compositing churn.

Total and Dissolved Trace elements in water (NWQL Lab Schedule 1995)

An unfiltered sample (**RA** -250 ml acid-rinsed polyethylene bottle) for trace-elements analysis will be collected directly from the churn. . The bottle will be twice-rinsed with unfiltered sample before being filled to the shoulder and acidified with 1:1 nitric acid to pH < 2. A second unfiltered sample (**RU** – 250-ml white polyethylene bottle) will be collected directly from the compositing churn after being twice-rinsed with unfiltered sample before being filled to the shoulder and placed on ice. A filtered sample for trace-elements analysis (NWQL Schedule 1995) will be taken from the compositing churn, processed through a 0.45-micron glass-fiber filter, and collected in a 250-ml acid-rinsed polyethylene bottle (**FA)** that will be twice-rinsed with filtered sample before being filled. Both filtered and unfiltered samples should be chilled to 4˚ C on ice, and shipped immediately to the NWQL.

Turbidity (NWQL LC 2187)

Samples for turbidity measurements will be collected directly from the compositing churn into a 500-ml polyethylene bottle (**TBY**), placed in a cooler on ice with other samples and shipped to the NWQL.

Grab Samples

Base/neutral/acid Extractables in water (NWQL LS 1494)

Samples for the analysis of base/neutral plus acid extractables (PAHs, NWQL Schedule 1494) will be collected during only 8 of the 15 storm-event collections at the four sites. These samples also will be collected as grab samples in 1-liter, amber, baked-glass bottles (**GCC**) by inserting the bottles into the water and allowing water to fill them to the shoulder. These samples will be labeled, chilled to 4˚C by placing on ice, and shipped to the NWQL without further processing.

Bed sediment grain-size distribution (Kentucky Lab)

At the end of the sample-collection series, a sample of the bed sediments deposited in the collection chamber of each of the four BMP structures will be collected and sent to the USGS Sediments Lab in Louisville, Kentucky. The sample will be collected by USGS standard protocol.

Comment [taa2]: INSERT PROTOCOL HERE from NFM.

Fecal coliform bacteria in water

Samples for fecal coliform bacteria analysis will be collected by hand in a 250- or 1,000-mL autoclaved bottle (Wilde and others, 1999), stored on ice, (Myers and Wilde, 1999), and processed within six hours of collection by personnel from the USGS office, in Columbia, South Carolina.

Oil and Grease in water (NWQL LC 2125)

The oil and grease sample (**OAG**) for each site is collected in a 1-liter amber, baked-glass bottle by inserting the bottle into the water and allowing water to fill it to the shoulder. The OAG sample will be preserved with 4 <; pg 18N sulfuric acid from a prepared ampule.

Bed Sediment Analyses for Inorganic Constituents (NWQL Schedule S803):

At the end of the sample-collection series, bed-sediments in the collection chamber of each BMP structure will be collected in 2 aliquots for the analysis of selected inorganic constituents (NWQL Lab ScheduleS803). Several shallow cores of sediment will be collected at each site. The cores will be placed in an acid-rinsed (5percent HCl) 3-quart pyrex® mixing bowl. The material will be composited and thoroughly mixed by stirring with an acid-rinsed Teflon spatula or HDPE stirring rod. The first aliquot will be prepared from the composited sample by placing material into an acid-rinsed 500-ml wide-mouth plastic jar to a depth of 2 centimeters. This sample requires no further special treatment/processing. The second aliquot will be prepared in like manner, but it will be chilled to 4 degrees C on ice and shipped overnight to the NWQL. Analyses will be conducted in accordance with procedures stipulated in Fishman and Friedman (1989) and in Garbarino and Struzeski (1998).

Sample Handling, Tracking and Custody Requirements:

Labeling, and Shipping

Samples from each of the four sites will be labeled with a unique USGS field identification number as the means for tracking each sample. Analytical Service Requests (ASR) that also are used as tracking/chain of custody forms (ASR) will be used to record data and will be submitted with the samples to the appropriate lab. Protocols for labeling, documenting, and packaging samples will be in accordance with Wilde and others (1999). Water quality samples, according to the sample type, will be preserved with acid following standardized protocols, put on ice, and shipped in insulated containers to the USGS NWQL in Denver, CO for analysis (Myers and Wilde, 1998). Five-day biological oxygen demand (BOD_5) samples will be stored on ice in insulated containers and transported to General Engineering Laboratories (GEL) at 2040 Savage Road, Charleston, SC. Point of contact at the lab is Martha Harrison (843 769-7389), who is project manager for GEL. Water-quality samples will be shipped priority overnight via Federal Express to the NWQL throughout the entire project. Bacteriological samples will be stored on ice, and processed within six hours of collection by USGS personnel.

Suspended Sediment Grain Size:

Suspended sediment samples from each of the four sites will be labeled with the unique USGS field identification number for that site as the means for tracking each sample. Protocols for labeling, documenting, and packaging samples will be in accordance with Wilde and others (1999). Samples for analysis of suspended sediment grain size will be closed with Teflon tape, to prevent loss of sample, and shipped to the USGS Sediment Laboratory in Kentucky.

Analytical Methods Requirements:

Water Chemistry Sample Processing:

All water chemistry and bed-sediment analyses will be conducted by the USGS NWQL in Denver, Colorado, utilizing standard USGS procedures. These procedures involve USEPA-certified approaches and meet all quality assurance and precision requirements for that agency. The NWQL has NELAC certification. Methods and quality assurance protocols are available at the following web site:http://wwwnwql.cr.usgs.gov/Public/pubs/QC_Fact/text.html. Determination of suspended-sediment particle size and bed-sediment grain distribution will be accomplished by the USGS Sediment Laboratory in Louisville, Kentucky. Methods and quality assurance protocols are available at http://ky.water.usgs.gov/projects/sed_lab/OFR_98_384.pdf .

Personnel from the USGS South Carolina District Office will analyze bacteriological samples in accordance with Wilde and others, 1999.

The parameters measured in water-quality samples are listed in Table 2 with NWQL lab codes, methods, and reporting and detection limits. Trace elements in whole water will be analyzed using Inductively Coupled Plasma - Mass Spectrometry (ICPMS) methods for cadmium, copper, lead, nickel, and zinc. Base/neutral extractable organic compounds (polyaromatic hydrocarbons) will be analyzed using gas chromatography and mass spectrometry methods (GC/MS). Nutrients will be analyzed by colorimetric-automated-segmented flow methods (C-ASF). This includes salicylate-hypochlorite (1), Microkjeldahl digestion (2), Cadmium-Reduction-diazotization (3), and Phosphomolybdate (4) methods. Bed-sediment inorganic constituents will be analyzed by inductively coupled plasma- optical emission spectrometry and inductively coupled plasma-mass spectrometry. Quality control samples (blanks and spikes) will be analyzed, using analytical methods described above, for all parameters.

Table 2. Description of NWQL Lab Schedule 1995 – Total and dissolved trace elements in water, total recoverable.

[M, method code; CAS, Chemical Abstracts Services; RL, reporting level; G, xxxxxx; ug/L, micrograms per Liter; lrl, laboratory reporting level; FA, acid-rinsed polyethylene bottle, 250-ml capacity, for filtered sample; I, xxxxxx; RA, acid-rinsed polyethylene bottle, 250-ml capacity, for raw sample; H, xxxxxx; B, xxxxxx; mrl, minimum reporting level, defined as the smallest measured concentration of a constituent that may be reported using a given method;; unsp, unspecified; pH, hydrogen ion concentration, expressed as negative log; uS/cm, microsiemens per centimeter]

Analyte	Lab Code	Parameter Code	M	CAS Number	RL	Unit	RL Type	Container
cadmium	1788	01025	G	7440-43-9	0.04	ug/L	lrl	FA
cadmium	2376	01027	I	7440-43-9	0.04	ug/L	lrl	RA
copper	2379	01042	H	7440-50-8	0.6	ug/L	lrl	RA
copper	1791	01040	G	7440-50-8	0.4	ug/L	lrl	FA
Digestion for trace metals	1735	99870	B			no.	mrl	RA
ICP Mass Spectrometry (ICPMS) setup	2182	L2182				unsp	mrl	RA
ICP Mass Spectrometry (ICPMS) setup	2181	L2181				unsp	mrl	FA
lead	1792	01049	G	7439-92-1	0.08	ug/L	lrl	FA
lead	2380	01051	I	7439-92-1	0.06	ug/L	lrl	RA
pH, laboratory	68	00403	A		0.1	pH	mrl	RU
specific conductance, laboratory	69	90095	A		2.6	uS/cm	mrl	RU
zinc	2390	01092	D	7440-66-6	2	ug/L	lrl	RA
zinc	1798	01090	G	7440-66-6	0.6	ug/L	lrl	FA

Table 3. Description of NWQL Lab Schedule 1040 – nutrients plus Microkjeldahl N and P

[M, method code; CAS, Chemical Abstracts Services; RL, reporting level; mg/L, milligrams per liter; lrl, laboratory reporting level; FCC, 125-ml brown polyethylene bottle; WCA, 125-ml white polyethylene bottle].

Analyte	Lab Code	Parameter Code	M	CAS Number	RL	Unit	RL Type	Container
phosphorus	1984	00665	D	7723-14-0	0.040	mg/L	lrl	WCA
nitrogen, ammonia + organic nitrogen	1986	00625	D	17778-88-0	0.10	mg/L	lrl	WCA

Table 5. Description of NWQL Schedule 1494 – Base Neutral plus Acid Extracbles (combined extracts of mono- and polycyclic aromatic hydrocarbons), in whole water.

[NWQL, National Water-Quality Laboratory; NWIS, National water information system; M, method code; CAS, Chemical Abstracts Services; RL, reporting level; GC/MS, gas chromatograph/mass spectrometry; ug/L, micrograms per Liter; mrl, minimum reporting level, defined as the smallest measured concentration of a constituent that may be reported using a given method; lrl, laboratory reporting level; A, xxx]

Analyte	NWQL Lab Code	NWIS Parameter Code	Method	CAS Number	RL/Unit	Reporting Level Type
2-Fluorobiphenyl(surrogate)	2327	49279	GC/MS	321-60-8	0.1 percent	mrl
Acenaphthene	1066	34205	GC/MS	83-32-9	1.8 µg/L	lrl
Acenaphthylene	1067	34200	GC/MS	208-96-8	1.8 µg/L	lrl
Anthracene	1068	34220	GC/MS	120-12-7	2.0 µg/L	lrl
Benz[a]anthracene	1070	34526	GC/MS	56-55-3	2.4 µg/L	lrl
Benzo[a]pyrene	1073	34247	GC/MS	50-32-8	2.8 µg/L	lrl
Benzo[b]fluoranthene	1071	34230	GC/MS	205-99-2	3.0 µg/L	lrl
Benzo[ghi]perylene	1074	34521	GC/MS	191-24-2	2.8 µg/L	lrl
Benzo[k]fluoranthene	1072	34242	GC/MS	207-08-9	3.2 µg/L	lrl
Chrysene	1082	34320	GC/MS	218-01-9	2.7 µg/L	lrl
Dibenz[a,h]anthracene	1083	34556	GC/MS	53-70-3	3.4 µg/L	lrl
Fluoranthene	1096	34376	GC/MS	206-44-0	2.4 µg/L	lrl
Fluorene	1095	34381	GC/MS	86-73-7	2.0 µg/L	lrl
Indeno[1,2,3-cd]pyrene	1101	34403	GC/MS	193-39-5	3.0 µg/L	lrl
Naphthalene	1103	34696	GC/MS	91-20-3	1.8 µg/L	lrl
Nitrobenzene	1104	34447	GC/MS	98-95-3	2.0 µg/L	lrl
Phenanthrene	1108	34461	GC/MS	85-01-8	2.0 µg/L	lrl
Pyrene	1109	34469	GC/MS	129-00-0	2.2 µg/L	lrl
Sample volume	1814	99855	A	-	1 mL	
set number,schedule 1383	1874	99813	A	-	no.	
Terphenyl-d14(surrogate)	2329	49278	GC/MS	1718-51-0	0.1 percent	mrl

Table 6. Description of NWQL ScheduleS803, trace metals in bottom material.

[M, method code; CAS, Chemical Abstracts Services; RL, reporting level; ug/g, micrograms per gram; mrl, minimum reporting level; CU, 500 mL Polypropylene bottle, wide-mouth, untreated; CC, 500 mL Polypropylene bottle, wide-mouth, chilled]

Analyte	Lab Code	Parameter Code	M	CAS Number	RL	Unit	RL Type	Container
Cadmium	2600	01028	C	7440-43-9	0.001	ug/g	mrl	CU
Chromium	2564	01029	C	7440-47-3	0.4	ug/g	mrl	CU
Cobalt	2601	01038	C	7440-48-4	0.001	ug/g	mrl	CU
Copper	2565	01043	C	7440-50-8	2	ug/g	mrl	CU
Iron	2566	01170	C	7439-89-6	2.1	ug/g	mrl	CU
Lead	2602	01052	C	7439-92-1	0.001	ug/g	mrl	CU
Manganese	2567	01053	B	7439-96-5	0.3	ug/g	mrl	CU
Mercury	511	71921	A	7439-97-6	0.01	ug/g	mrl	CU
Nickel	2604	01068	C	7440-02-0	0.001	ug/g	mrl	CU
Phosphorus	515	00668	B	7723-14-0	40	mg/kg	mrl	CC
Zinc	2568	01093	B	7440-66-6	3.1	ug/g	mrl	CU

Quality Control Requirements:

Sediment analysis

Quality assurance (QA) and quality control (QC) for the sediment analysis procedures will be accomplished by collecting and analyzing field replicates and duplicate samples. Criteria for acceptance require that a difference of no greater than 10 percent may exist in the dominant component, representing either sand or silt/clay combined for each sample. If the absolute difference between the original number and the second (QA/QC) number is greater than 10 percent then a different technician will complete a third analysis. The values closest to the third value will be entered into the database. If more than 10 percent of the data from a batch are in error, then the Lab Manager and Co-Investigators will meet to discuss an appropriate plan for reprocessing the sample batch using the archived sediment, retraining lab staff as necessary. Quality control procedures will be applied to the reanalyzed batch as well. Re-analyses and QA/QC checks are dependent upon having enough sediment to complete them. Sediment

particle size and pore water ammonia precision is 10 percent. Pore-water ammonia accuracy is +/- 0.01 mg/L.

Bed-Sediment Analyses:

The NWQL will analyze the sediment samples from each structure for inorganic constituents. Metals QA/QC methods will include several precautions to avoid contamination during metals analysis. A dilute solution (3 percent by volume) of HNO_3 is used to clean the glassware prior to analysis and to rinse the filter paper prior to filtering the samples. Two types of blanks are analyzed as a check for contamination. The first blank consists of a 15 percent nitric acid solution and is used as the endpoint of the daily calibration curve. The second blank (a method blank) is a solution that was processed using the extraction procedure to check for contamination that may arise during the digestion process. The limit of detection (LOD) for each element analyzed will be determined from the blank information as the mean blank plus three times the standard deviation. To evaluate the efficiency of the nitric acid microwave digestion procedure, a NIST standard reference material will be analyzed.

Water Chemistry Analyses:

Rigorous QA/QC procedures will be followed, with at least 10 percent of the analyses made for QA purposes (Wilde and others, 1999; Wagner and others, 2000). Samples for QA/QC will include (1) field and equipment blanks to ensure that the sampler, intakes lines, churns, and bottles are not contaminating samples; (2) split samples to document reproducibility of laboratory results; and (3) concurrent samples to demonstrate that the automatically-collected point sample is representative of the cross-sectional mean concentration. Standard reference samples also are used at the USGS laboratories as part of their QA/QC procedures.

To document the quality of field measurements, all USGS personnel involved in the collection of water quality data are required to participate in the National Field Quality Assurance (NFQA) Program (Stanley

and others, 1992; Stanley and others, 1998). The NFQA Program uses standard reference solutions to test the accuracy of field meters with respect to alkalinity, pH, and specific conductance. The Regional Hydrologist and the District Water Quality Specialist review results of the NFQA Program.

Project and Discipline Reviews:

Project reviews are conducted periodically by SC District management, technical advisors, or discipline specialists to ensure compliance with the project workplan or proposal. Project reviews are used to ensure that data collection, analysis, and reporting are done in accordance with USGS policy. The South Carolina District is reviewed every three years by the Office of Surface Water, Office of Water Quality, and Office of Groundwater in Reston, VA, to ensure that the South Carolina District operation is in accordance with the National standards of the USGS.

Instrument/Equipment Testing, Inspection, and Maintenance Requirements:

All project staff operating in-place continuous monitoring or field-portable instruments are required to demonstrate proficiency in their performance of the collection of water quality samples and data. Particular emphasis is placed on the proper maintenance and calibration of the monitoring instruments.

USGS Calibration Checks and QC Procedures:

Immediately before deployment, all units selected for long-term deployment will be re-checked to insure steady readings and reliable performance. Following a deployment period, instrument performance will again be evaluated in the laboratory by comparing readings against calibration standards. The results will be documented on the same data sheet used before deployment. The follow-up QC checks after retrieval help to ascertain that the instrument was functioning properly during the logging run (within tolerances stated in Table 3). If the instrument's values exceed the tolerance range, the field team will consult with the Co-Investigators for further instructions regarding re-deployment. Acceptable differences are shown in Table 7

Table 7 Maximum acceptable differences for instrument calibration and field QC checks

Instrument	Frequency of Check	Parameter	Checked against	Maximum Acceptable Difference
Hydrolab	Pre and post	Temperature	Thermometer	± 2.5°C
YSI, Stevens	deployment	Salinity	KCl standard	± 1.6 ppt
multiprobes	calibration	percent Sat. D.O.	100percent air saturation	± 10 percent
		pH	pH buffer solutions	± 0.7 pH units
YSI 85	each station	percent Sat. D.O.	100 percent air saturation	± 10 percent
Hanna pHep	each station	pH	pH buffer solutions	± 0.7 pH units

Water Level and Stream Velocity:

Stream stage (water level) will be continuously monitored, using a pressure transducer. Calibration and maintenance will be in accordance with the equipment manufacturer's guidelines. Flow will be measured an electromagnetic flow meter, with calibration and maintenance performed in accordance with the equipment manufacturer's guidelines.

Storm-Event Water-Quality Parameters:

Field parameters, including temperature, conductivity, pH, and dissolved oxygen, will be measured during storm events with a Hydrolab Minisonde or Reporter® instrument in accordance with Wilde and others (1999). The proper calibration and maintenance for the Hydrolab instruments will be in accordance with the respective user's manuals. Field measurements should represent the natural conditions of the system at the time of sampling. To ensure quality of the measurements, calibration within the range of field conditions at each site is required.

The calibration of the dissolved oxygen sensor is based on a reading of 100percent saturation in a water saturated air environment. The USGS calibrated accuracy of the DO sensor should be within the lesser of 5 percent or +/- 0.3 mg/L (Wagner and others, 2000). The calibration of the conductivity sensor is calibrated using a KCL standard that is equivalent to the specific conductance of the field conditions. The calibrated accuracy of the sensor should be within 5 percent for specific conductance values less than

or equal to 100 uS/cm, or within 3 percent for specific conductance values more than 100uS/cm (Wagner and others, 2000). The calibration of the pH sensor is a two point calibration curve established with standard buffer solutions of pH 7.0 and 10.0. The accuracy of the pH sensor should be at least +/- 0.1 pH unit. The temperature sensor is factory calibrated and cannot be adjusted. The accuracy of the temperature sensor should be within +- 0.2 ^{o} C, when compared with a NIST-certified thermometer in the lab.

Inspection/Acceptance Requirement for Supplies:

Project staff that receive supplies will immediately check the order to ensure that all items meet order specifications. Any problems will be identified to the Project Supervisors for resolution.

Assessment and Oversight

Sample Tracking:

All samples will be tracked using a comprehensive system for labeling of sample containers, recording sampling information in the field, and tracking sample shipments using chain of custody forms. The laboratory responsible for processing each sample must designate a sample custodian, sign for the incoming field samples, and verify sample custody records. This individual is required, upon receipt of samples, to record all tracking information. Laboratory personnel should be aware of the required sample holding times and conditions. Any discrepancies in the tracking form and the shipment should be noted immediately upon receipt. The laboratory supervisor should notify the Project Leader within five working days of any discrepancy that is not immediately resolved.

Data Reporting Requirements and Evaluation Procedures:

Data generated from the samples processed will be entered into the USGS national water quality database directly from the USGS NWQL in Denver, or from the local lab, where applicable. Quantity

data that is collected and relayed via telemetry in almost real time will be available on the USGS web site when received. Stewardship of the transferred data will rest with the Program Manager for this project. Spatial data sets will be accompanied by metadata to adhere to federal metadata standards, where appropriate.

Data Validation and Usability

The quality of the data will be evaluated prior to any data being placed into a database or released for public consumption. This will be done by comparing printouts of the electronic files with the original field and laboratory data forms, and by evaluating obvious data outliers in electronic data files obtained from deployed instrumentation. All errors encountered will be re-entered. Project Managers and the Co-Investigators from each agency will review all data processing and data deliverables created by their agency as part of their job responsibilities. Water-quality data from each sampled event will be reviewed for quality assurance when received from the laboratory and the data will be made available through the USGS National Water Information System (NWIS) data base once accuracy is verified.

In addition, the SCDOT will provide average daily traffic (ADT) data. The USGS will use these data and and similar data from other investigations and attempt to correlate types of constituents measured with the ADT for each site.

Reports to Management:

Progress reports will be provided to the SCDOT quarterly. In addition, data from each sampled event will be available once received from the laboratory and accuracy has been verified. Following the data-collection phase, event loads will be calculated for the inflow and outflow for each structure. The load data will be used to estimate removal efficiencies and determine the effectiveness of the devices in reducing suspended sediment, selected metals, nutrients, and organics concentrations. A Scientific

Investigations Report that evaluates the effectiveness of the 4 BMPs will be published by USGS during the third year of the project. This report also will be available on the web.

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Appendix: Data Collection and Management Forms:

APPENDIX 1: "Best Management Practices program"

Application for Federal Assistance submitted August 2, 2001 to U.S. Environmental Protection Agency by the SC-DOT Department of Public Service, C. Werner and L. Cabiness, EMPACT Program Sorting Code 2001-NCER-J1, "Best Management Practices program", 18 p.

APPENDIX 2: USGS National Water Quality Laboratory Analytical Services Request Form.

U.S. GEOLOGICAL SURVEY – NATIONAL WATER QUALITY LABORATORY
ANALYTICAL SERVICES REQUEST

THIS SECTION MANDATORY FOR SAMPLE LOGIN

NWIS RECORD NUMBER SAMPLE TRACKING ID	User Code	Project Account	LAB USE ONLY NWQL LABORATORY ID

STATION ID	Begin Date (YYYYMMDD)	Begin Time	Medium Code	Sample Type

803 750-6131 **District Contact Phone Number**	End Date (YYYYMMDD)	End Time	**District Contact Email**

SITE / SAMPLE / SPECIAL PROJECT INFORMATION (Optional)

State	County	Geologic Unit Code	Analysis Status*	Analysis Source*	Hydrologic Condition*	Hydrologic Event*	Chain of Custody	Sample Set

CL03SANT NWQL Proposal Number	NWQL Contact Name	NWQL Contact Email	Program/Project

Station Name: Field ID:

Comments to NWQL:

Hazard (please explain):

ANALYTICAL WORK REQUESTS: SCHEDULES AND LAB CODES (CIRCLE A=add D=delete)

SCHED 1:	SCHED 2:	SCHED 3:	SCHED 4:	SCHED 5:	SCHED 6:

Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D
Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D
Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D	Lab Code: A D

SHIPPING INFORMATION (Please fill in number of containers sent)

ALF COD FA FCN IQE IRM RA RU SUR TPCN

___BGC	___CRB	___FAM		___IQL	___MBAS	___RAM	___RUR	___SUSO	___UAS
___C18	___CU	___FAR	___FUS	___IQM	___OAG	___RAR	___RURCT	___TBI	___WCA
___CC	___CUR	___FCA	___GCC	___IRE	___PHE	___RCB	___RURCV	___TBY	
___CHY	___DOC	___FCC	___GCV	___IRL	___PIC	___RCN	___RUS	___TOC	___ ______

NWQL Login ____________________

____

Collected ____________ Phone ____________ Date ____________

FIELD VALUES

Lab/P Code	Value	Remark	Lab/P Code	Value	Remark	Lab/P Code	Value	Remark
21/00095 Specific Conductance uS/cm @ 25 deg C			51/00400 pH Standard Units			2/39086 Alkalinity – IT mg/L as CaCO3		
___/______			___/______			___/______		

Field Cmments: ____________________

____

*MANDATORY FOR NWIS

Revised 04/00

PLEASE USE BLACK INK ONLY

INSTRUCTIONS FOR COMPLETING ANALYTICAL SERVICES REQUEST FORM

***SAMPLE IDENTIFICATION** (Mandatory)*

NWIS Record No.	-	Record number of sample assigned by NWIS database (District)
User Code	-	Enter District user code (indicates which office sample data are to be directed)
Project Acct	-	Enter 9 digit account number
NWQL Laboratory ID	-	Leave blank (for Laboratory use only)
Station ID	-	Enter downstream order number, 15 digit latitude, longitude and sequence number or unique sample identifier
Begin Date (YYYYMMDD)	-	Enter 4 digit number for year, 2 digit number for month, 2 digit number for day sample collection started
Begin Time	-	Enter 4 digit military time sample collection started
Medium Code	-	Enter sample medium code (see attached table)
Sample Type	-	Enter sample type code (see attached table)
District Contact Phone Number	-	Enter complete phone number for District contact for sample questions or problems
End Date (YYYYMMDD)	-	Enter 4 digit number for year, 2 digit number for month, 2 digit number for day sample collection ended
End Time	-	Enter 4 digit military time sample collection ended
District Contact Email	-	Enter complete email address for District contact for sample questions or problems

SITE / SAMPLE / SPECIAL PROJECT INFORMATION (Optional)

State	-	Enter 2 digit FIPS code for State in which station is located
County	-	Enter 3 digit FIPS code for county in which station is located
Geologic Unit Code	-	Enter geologic unit code for ground-water sample (multiple aquifer identification)
*Analysis Status	-	Enter analysis status code (see attached table)
*Analysis Source	-	Enter analysis source code (see attached table)
*Hydrologic Condition	-	Enter hydrologic condition code (see attached table)
*Hydrologic Event	-	Enter hydrologic event code (see attached table)
Chain of Custody	-	Enter Y if sample is chain of custody
Sample Set	-	Enter identifier for sample set, and place on all bottles and associated log form, for example: "A", "BB" (max. 2)
NWQL Proposal Number -	-	Denotes non-routine or custom work assigned by NWQL in negotiated proposal
NWQL Contact Name	-	Enter name of NWQL person to be contacted when sample arrives at Lab
NWQL Contact Email	-	Enter email of NWQL person to be contacted when sample arrives at Lab
Program/Project	-	For example: NAWQA, NASQAN, NPDES, DW - if applicable
Station Name	-	Enter local station name
Field ID	-	Enter identification assigned by District
Comments to NWQL	-	Enter information about sample that NWQL should be aware of (high concentration, etc.)
		Note: Samples collected for analysis by Geologic Division **MUST** have the latitude/longitude provided for login
Hazard	-	Describe any known hazard associated with sample (chemical, biological, radiological, etc.)

ANALYTICAL WORK REQUESTS: SCHEDULES AND LAB CODES

Schedule	-	Enter schedule number(s) for the desired analyses.
Lab Code	-	Enter lab code for analyses to be added or deleted. Circle "A" for addition or "D" for deletion. Maximum 15.

SHIPPING INFORMATION (Please fill in number of sample types sent)

NWQL Login Comments	-	NWQL login personnel comments.
Collected by:	-	Enter name of individual that collected/shipped samples
Phone No.	-	Enter phone number of individual that collected/shipped samples
Date Shipped	-	Enter date samples packed/shipped to NWQL.

FIELD VALUES

Lab/P Code/Value/Remark	-	Enter values and remarks for sc, pH, alk, if needed, enter P code, value, remark for other field values
Field Comments	-	For field use only. Will not be used by NWQL.

*Mandatory for storage in NWIS

APPENDIX 3: USGS Surface Water Field Sheet